IceBridge MCoRDS L2 Ice Thickness, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Paden, J., J. Li, C. Leuschen, F. Rodriguez-Morales, and R. Hale. 2010, updated 2019. *IceBridge MCoRDS L2 Ice Thickness, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/GDQ0CUCVTE2Q. [Date Accessed].

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National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

The data set includes measurements for ice elevation, ice surface, ice bottom, and ice thickness.

1.2 File Information

1.2.1 Format

The data files are in comma-separated values (`.csv`) format. Each data file is paired with an associated XML (`.xml`) file, which contains additional metadata.

The radar data are divided into segments. A segment is a contiguous data set in which the radar settings do not change. A day is divided into segments if the radar settings were changed, hard drives were switched, or other operational constraints required that the radar recording be turned off and on. The segment ID is YYYYMMDD_SS where YYYY is the four-digit year, MM is the two-digit month from 1 to 12, DD is the two-digit day of the month from 1 to 31, and SS is the segment number from 0 to 99. Segments are always sorted in the order in which the data were collected. Generally, SS starts with 1 and increments by 1 for each new segment, but this is not always the case; only the ordering is guaranteed to match the order of data collection.

1.2.2 File Naming Convention

The files are named according to the following convention, which is described in more detail in Table 1.

```
IRMCR2_YYYYMMDD_SS.xxx
IRMCR2_20181116_02.csv
```

Table 1. File Naming Convention

Variable	Description
`IRMCR2`	Data set ID
`YYYY`	4-digit year
`MM`	2-digit month
`DD`	2-digit day
`SS`	flight segment number
`.xxx`	Indicates file type, e.g., `.csv` or `.xml`

1.2.3 File Contents

Below is an excerpt from data file `IRMCR2_20181116_02.csv`. The fields in each record correspond to the columns described in Table 5.

IRMCR2_20181116_02								
LAT	LON	UTCTIMESOD	THICK	ELEVATION	FRAME	SURFACE	BOTTOM	QUALITY
-74.288328	-89.844690	65439.6468	-9999.00	4021.7275	2018111602001	2919.06	-9999.00	1
-74.288434	-89.844993	65439.7230	-9999.00	4020.9194	2018111602001	2917.13	-9999.00	1
-74.288540	-89.845297	65439.7991	-9999.00	4020.1113	2018111602001	2915.56	-9999.00	1
-74.288646	-89.845600	65439.8753	-9999.00	4019.3025	2018111602001	2914.40	-9999.00	1
-74.288752	-89.845904	65439.9515	-9999.00	4018.4958	2018111602001	2913.37	-9999.00	1
-74.288858	-89.846207	65440.0277	-9999.00	4017.6900	2018111602001	2912.48	-9999.00	1
-74.288964	-89.846511	65440.1039	-9999.00	4016.8840	2018111602001	2911.64	-9999.00	1
-74.289070	-89.846814	65440.1801	-9999.00	4016.0760	2018111602001	2910.78	-9999.00	1
-74.289176	-89.847118	65440.2563	-9999.00	4015.2668	2018111602001	2909.65	-9999.00	1
-74.289282	-89.847421	65440.3325	-9999.00	4014.4591	2018111602001	2908.57	-9999.00	1

1.3 Spatial Information

1.3.1 Coverage

Spatial coverage for the IceBridge Multichannel Coherent Radar Depth Sounder (MCoRDS) campaigns includes Antarctica, the Arctic, and Greenland.

Antarctica:
Southernmost Latitude: 90.0° S
Northernmost Latitude: 57.0° S
Westernmost Longitude: 180.0° W
Easternmost Longitude: 180.0° E

Arctic and Greenland:
Southernmost Latitude: 59.0° N
Northernmost Latitude: 83.1° N
Westernmost Longitude: 100.2° W
Easternmost Longitude: 28.5° E

1.3.2 Resolution

Spatial resolution varies by surface characteristics and aircraft flown, as shown in Table 2.

Table 2. Spatial Resolution by Surface Type and Aircraft

Aircraft	Smooth surface, across-track, Fresnel-limited	Rough surface, across-track, pulse-limited	Rough surface, across-track, beamwidth-limited	Along-track	Depth
DC-8	71 m where height above the air/ice interface = 500 m and ice thickness = 2000 m 168 m where aircraft height = 8000 m and ice thickness = 2000 m	641 m where aircraft height = 500 m and ice thickness = 2000 m 1518 m where aircraft height = 8000 m and ice thickness = 2000 m	965 m where aircraft height = 500 m and ice thickness = 2000 m 5416 m where aircraft height = 8000 m and ice thickness = 2000 m	About 25 m and a sample spacing of about 14 m	17.8 m
P-3	71 m where height above the air/ice interface = 500 m and ice thickness = 2000 m	323 m where height above the air/ice interface = 500 m and ice thickness = 2000 m	651 m where height above the air/ice interface = 500 m and ice thickness = 2000 m	~25 m and a sample spacing of ~14 m	4.5 m[1]
Twin Otter	71 m where height above the air/ice interface = 500 m and ice thickness = 2000 m	316 m where height above the air/ice interface = 500 m and ice thickness = 2000 m	576 m where height above the air/ice interface = 500 m and ice thickness = 2000 m	~25 m and a sample spacing of ~14 m	4.5 m
C-130	56 m (270 MHz bandwidth) and 69 m (50 MHz bandwidth) where height above the air/ice interface = 500 m and ice thickness = 2000 m	106 m (270 MHz bandwidth) and 245 m (50 MHz) where height above the air/ice interface = 500 m and ice thickness = 2000 m	4783 m (270 MHz bandwidth) and 6698 m (50 MHz bandwidth) where aircraft height = 500 m and ice thickness = 2000 m	~25 m and a sample spacing of ~14 m	0.5 m (270 MHz bandwidth) 2.6 m (50 MHz bandwidth)
GV	64 m where height above the air/ice interface = 500 m and ice thickness = 2000 m	408 m where aircraft height = 500 m and ice thickness = 2000 m	1253 m where aircraft height = 500 m and ice thickness = 2000 m	~25 m and a sample spacing of ~14 m	7.2 m

[1]Actual target location is ambiguous for a rough surface since the off-nadir returns in the antenna footprint can hide the nadir return; ice thickness is nearly correct but may not be for the nadir return.

1.3.3 Geolocation

Table 3. Geolocation Details for the Antarctic Campaigns.

Geographic coordinate system	WGS 84
Projected coordinate system	Antarctic Polar Stereographic
Longitude of origin	0°
Standard parallel	-71°
Datum	WGS 84
Ellipsoid/spheroid	WGS 84
Units	meters
EPSG code	3031
PROJ4 string	+proj=stere +lat_0=-90 +lat_ts=-71 +lon_0=0 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs +type=crs
Reference	https://epsg.io/3031

Table 4. Geolocation Details for the Arctic Campaigns.

Geographic coordinate system	WGS 84
Projected coordinate system	NSIDC Sea Ice Polar Stereographic North
Longitude of origin	-45°
Standard parallel	70°
Datum	WGS 84
Ellipsoid/spheroid	WGS 84
Units	meters
EPSG code	3413
PROJ4 string	+proj=stere +lat_0=90 +lat_ts=70 +lon_0=-45 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs +type=crs
Reference	https://epsg.io/3413

1.4 Temporal Information

1.4.1 Coverage

16 October 2009 to 20 November 2019

1.4.2 Resolution

IceBridge campaigns were conducted annually from 2009 to 2019. Arctic and Greenland campaigns were typically conducted in March, April, and May; Antarctic campaigns were typically conducted in October and November.

1.5 Parameter or Variable

1.5.1 Parameter Description

The `.csv` files contain fields as described in Table 5.

Table 5. File Parameters, Description, and Units

Parameter	Description	Units
`LAT`	Latitude	degrees north
`LON`	Longitude	degrees east
`UTCTIMESOD`	UTC time	seconds of day
`THICK`	Ice thickness: `Bottom` minus `Surface`. Constant dielectric of 3.15 (no firn) is assumed for converting propagation delay into range. -9999 indicates no thickness available.	meters
`ELEVATION`	Elevation referenced to WGS-84 Ellipsoid.	meters
`FRAME` (YYYYMMDDSSFFF)	Fixed length numeric field. YYYY = year, MM = month, DD = day, SS = segment, FFF = frame.	N/A
`SURFACE`	Range to ice surface. Actual surface height is `Elevation` minus this number.	meters
`BOTTOM`	Range to ice bottom. Actual ice bottom height is `Elevation` minus this number. Constant dielectric of 3.15 (no firn) is assumed for converting propagation delay into range. -9999 indicates no thickness available.	meters
`QUALITY`	1: High confidence pick 2: Medium confidence pick 3: Low confidence pick	N/A

Note: When aligning with GPS time tagged data, account for leap seconds.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

Ice thickness is typically determined using data collected from waveforms with different pulse durations. Generally, all receive channels are used to produce the best result. The two reflections that are of most interest are the ice surface and ice bottom. The difference in the propagation time between the ice surface and ice bottom reflections is then converted into ice thickness using an estimated index of refraction of ice (square root of 3.15). The media is assumed to be uniform, i.e., no firn correction is applied.

2.2 Instrumentation

MCoRDS operates over a 180 to 210 MHz frequency range with multiple receivers developed for airborne sounding and imaging of ice sheets. Measurements are made over two frequency ranges: 189.15 to 198.65 MHz and 180 to 210 MHz. The radar bandwidth is adjustable from 0 to 30 MHz. Multiple receivers permit digital beamsteering for suppressing cross-track surface clutter that can mask weak ice-bed echoes and strip-map SAR images of the ice-bed interface. These radars are flown on twin engine and long-range aircraft including NASA P-3, Twin Otter (TO), and DC-8. GPS time corrections and frames where no reliable sync information was available are given in the records worksheet in the Parameter Spreadsheet.

2.3 Acquisition

The signal detection method by aircraft and altitude is described below. A list of settings for the instrument setup is provided in Appendix A.

P-3 Low Altitude

A large dynamic range of signal powers is observed, so two waveforms are used. A waveform with a 1 µs duration and low receiver gain is used to measure the round-trip signal time for the surface echo, while a waveform with a 10 µs duration and high receiver gain is used to measure the round-trip signal time for the bed echo. Note that the 10 µs signal is generally saturated from the ice surface and upper internal layers.

DC-8 Low Altitude

The same concept is used as for P-3. However, during the first two field seasons (2009 Antarctica DC-8 and 2010 Greenland DC-8), extra antennas inside the cabin were used to detect the ice surface delay time because the Transmit/Receive (TR) switches did not meet their switching time specification. In subsequent field seasons, the TR switch control signals were set so that the surface echo was generally still detectable, although with diminished power, even for very low altitudes down to 600 feet Above Ground Level (AGL).

P-3 High Altitude and DC-8 High Altitude

The dynamic range between the ice surface and ice bottom echoes is relatively small, and a single high-gain and long-pulse duration waveform is used to capture both echoes.

Twin Otter

Only low-altitude data with waveforms of 1 µs and 10 µs were used, as with P3. A waveform of 20 µs duration was used during some flights to detect the ice bed of the deepest part of the Byrd Glacier trunk.

C-130

Two waveforms of 1 µs and 3 µs duration were used during some flights. Three waveforms of 1 µs, 3 µs, and 10 µs duration were used during other flights. Four waveforms of 1 µs, 3 µs, 10 µs, and 10 µs duration were also used during some flights.

GV

Two waveforms of 1 µs and 3 µs duration were used during low-altitude flights, and two waveforms of 1 µs and 10 µs were used during high-altitude flights.

2.4 Processing

The layer tracking of ice surface and ice bottom reflections is a manually driven process with basic tools for partial automation. The tools used are determined by the operator selecting the data and include:

1. Manual picking and interpolation.
2. Viterbi tracker.
3. Snake tracker that follows the strongest return within a window centered on the last tracked location from range line to range line.
4. Leading edge detector searches for the crossing of a threshold beneath the peak return.
5. Peak detector.

Various processing outputs, such as Minimum Variance Distortionless Response (MVDR), standard, quick look, dynamic range of the image, averaging, and detrending methods, are used to better highlight features in the echogram as needed.

For further details on data processing, including algorithms, see the Data Processing section in the *IceBridge MCoRDS L1B Geolocated Radar Echo Strength Profiles* documentation.

2.5 Quality, Errors, and Limitations

The data are not radiometrically calibrated. This means that they are not converted to an absolute standard for reflectivity or backscattering analysis. The MCoRDS science team is working on data processing and hardware modifications to do this.

The primary error sources for ice-penetrating radar data are system electronic noise, multiple reflectors also known as multiples, and off-nadir reflections. Each of these error sources can create spurious reflections in the trace data leading to false echo layers in profile data. Multiple reflectors arise when the radar energy reflects off two surfaces more than once (or resonates) in the vertical dimension, and then returns to the receive antenna. Reflections occur in situations when two or more large reflectors are present with large electromagnetic constitutive property changes, such as the ice surface (air/ground), the bottom of the ice, and the aircraft body which is also a strong reflector. The radar receiver only records time since the radar pulse was emitted, so the radar energy that traveled the additional path length appears later in time, apparently deeper in the ice or even below the ice–bedrock interface. Note that multiples of a strong continuous reflector have a similar shape because the propagation time is a multiple of the resonance cavity. The most common multiple is between the air–ice surface and the aircraft. This "surface" multiple shows up at twice the propagation time as the original surface return and all the slopes are doubled.

Off-nadir reflections can result from crevasse surfaces, water, rock outcrops, or metal structures. Antenna beam structure and processing of the data are designed to reduce these off-nadir reflected energy sources.

2.5.1 Campaign-Specific Issues

2009 Antarctica DC-8

- TR Switch: During the first two field seasons (2009 Antarctica DC-8 and 2010 Greenland DC-8), extra antennas inside the cabin were used to detect the ice surface delay time because the TR switches did not meet their switching time specification. The TR switches have not been fixed in subsequent field seasons, but the TR switch control signals have been set so that the surface echo is generally still detectable (with diminished power), even for very low altitudes down to 600 ft AGL.
- Some of the data collected during this season are from high altitudes. The high-altitude data are generally lower quality than the low-altitude data because (1) the cross-track antenna resolution is proportional to range creating severe layover problems in mountainous terrain, for example, the 05 November 2009 high-altitude peninsula flight; (2) the sidelobes from the long-pulse duration mask out some of the returns that otherwise would have had a high enough signal-to-noise ratio, and (3) the range to target is greater such that the spherical spreading power loss is greater leading to a lower signal-to-noise ratio.
- Monostatic elements: All monostatic elements used for transmit and receive have an unknown fast-time gain profile because the TR switches take about 10 microseconds to fully switch positions. This fast-time gain profile has not been corrected so that using the surface or shallow layer returns for antenna equalization or for radiometric purposes is not recommended. All five of the antennas on the DC-8 are monostatic antennas.

2010 Antarctica DC-8

- TR Switch: This is a similar problem as with the 2009 Antarctica DC-8 season. However, we were able to set the TR switch control signals so that the surface is recoverable with the regular array down to an altitude of 600 ft AGL but with very reduced signal strength. The regular array is preferred over the EMI antenna setup because the radiation pattern characteristics are better. At an altitude of 1,500 ft, no degradation in signal detectability is observed.
- High-altitude data: See 2009 Antarctica DC-8.
- Monostatic elements: See 2009 Antarctica DC-8.

2010 Greenland DC-8

- One of the in-cabin Electromagnetic Interference (EMI) antennas is used to produce the quicklook data product. The EMI antennas were not designed to receive the surface return. However, the TR switch for the primary array was set so that the surface returns for platform altitudes below 1,500 ft were greatly attenuated. Therefore, the EMI antennas are used for picking the surface return at low altitude.

2010 Greenland P-3

- Monostatic elements: See 2009 Antarctica DC-8. Only the center seven elements are monostatic on the P-3.
- EMI: Due to lack of shielding, a noisy switching power supply, and potentially other unidentified sources, the radar was operated with 10 MHz bandwidth (190-200 MHz) for most of the field season. The signal quality is still lower than expected in this band due to broadband noise which is present at all times and periodic burst noise from other pulsed instruments on the P-3 and from random burst noise. The persistent noise manifests itself as an increase in the noise floor and the burst noise manifests itself as smeared point targets.

2011 Greenland P-3

- The MCoRDS2 data acquisition system fielded for the first time this season has a known issue with radar data synchronization with GPS data. The synchronization time correction that must be added to the radar time stamp is either 0 or -1 seconds. When the radar system is initially turned on, the radar system acquires UTC time from the GPS National Marine Electronics Association (NMEA) string. If this is done too soon after the GPS receiver has been turned on, the NMEA string sometimes returns GPS time rather than UTC time. GPS time is 15 seconds ahead of UTC time during this field season. The corrections for the entire day must include the offset, either -15 or -16 seconds. GPS corrections have been applied to all of the data using a comparison between the accumulation radar and the MCoRDS radar. The accumulation radar from 2011 is known to have only the GPS/UTC problem. The GPS/UTC problem is easily detectable by comparing the data to raster imagery, so the only correction that could be in error is the 0 or -1 second offset; this generally occurs when there are no good features in or above the ice to align the accumulation and MCoRDS2 radars. GPS time corrections and frames where no good sync information was available are given in the records worksheet of the Parameter Spreadsheet.

- Two of the missions, SE Glaciers on 11 April 2011 and Helheim/Kanger/Midguard on 19 April 2011, suffered from radar configuration failures and about 40 dB of sensitivity was lost on the high-gain channel. Short portions of these data are still good so the datasets are published, but most of the data are not useful. Currently, recovery is not possible.
- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. Only the center seven elements are monostatic on the P-3.
- TR Switch: See 2010 Greenland P3.

2011 Antarctica DC-8

- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8.
- TR Switch: See 2010 Greenland P3.

2011 Antarctica TO

- This field season concentrated on Byrd Glacier and its catchment area. No high-altitude data were collected, and no coincident LIDAR data are available for this season.
- High speed GaNi/hybrid TR switches with circulator installed with 100 ns switching time. This fixes the TR switching time problem described in 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. Six TR channels are monostatic installed on the right wing, and 6 receive-only channels installed on the left wing.

2012 Greenland P-3

- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. Only the center seven elements are monostatic on the P-3.
- TR Switch: See 2010 Greenland P3.

2012 Antarctica DC-8

- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8.
- High speed GaNi/hybrid TR switches with circulator installed with 100 ns switching time. This fixes the TR switching time problem described in 2009 Antarctica DC8 and 2010 Greenland P3.

2013 Greenland P-3

- Only the center seven antenna elements were installed to reduce costs.
- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. All the center seven elements are monostatic on the P-3.

2013 Antarctica P-3

- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. Only the center seven elements are monostatic on the P-3.

2014 Greenland P-3

- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. Only the center seven elements are monostatic on the P-3.

2014 Antarctica DC-8

- New antenna array installed. New power amplifiers (1800 W of power) and receivers installed to support 165-215 MHz bandwidth. New digital system sampling frequency to support new bandwidth.
- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8.

2015 Greenland C-130

- New wideband antenna installed with 2 elements. New digital system installed. New transmitter and receiver installed to support 180-450 MHz bandwidth.
- Small antenna aperture: The antenna aperture is very small with two very closely spaced elements and therefore the cross-track resolution is very coarse leading to higher clutter compared with other seasons.
- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. Both elements are monostatic.

2016 Greenland P-3

- The wideband antenna of 180-450 MHz bandwidth with 2 elements, digital system, transmitter and receiver used in 2015 Greenland C-130 were used on NOAA P-3.
- Small antenna aperture: The antenna aperture is very small with two very closely spaced elements and therefore the cross-track resolution is very coarse leading to higher clutter compared with other seasons.
- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. Both elements are monostatic.

2016 Antarctica DC-8

- The antenna array, power amplifiers, receivers, bandwidth and digital system sampling frequency were the same as in 2014 Antarctica DC-8.
- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8.

2017 Greenland P-3

- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. Only the center seven elements are monostatic on the P-3.
- Accumulation radar created noise on MCoRDS receivers. Solved by adding filters to accumulation radar transmit.
- Science data system cables routed near MCoRDS center element cables caused elevated noise. Solved by improving routing and adding ferrite chokes to RF cables.
- Added IMU-GPS measurements in each wing tip, causing a small increase in noise on the right wing.

2017 Antarctica P-3

- The antenna array, power amplifiers, receivers, bandwidth, and digital system sampling frequency were the same as in 2014 Antarctica DC-8.
- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. Only the center seven elements are monostatic on the P-3.

2017 Antarctica Basler

- No high-altitude data.
- Monostatic elements: See 2009 Antarctica DC8. All the eight elements installed under the Basler's fuselage are monostatic.

2018 Antarctica DC-8

- The antenna array, power amplifiers, receivers, bandwidth and digital system sampling frequency were the same as in 2014 Antarctica DC-8.
- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8.

2019 Greenland P-3

- Only seven antenna elements installed under the fuselage.
- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. All the center seven elements are monostatic on the P-3.

2019 Antarctica GV Specific Issues

- High-altitude data: See 2009 Antarctica DC8.
- Monostatic elements: See 2009 Antarctica DC8. All the center four elements are monostatic on the GV.

3 VERSION HISTORY

Table 6. Version History Summary

Version	Release Date	Description of Changes
V1.0	July 2010	Initial release.
V1.1	April 2011	2009 Antarctica MCoRDS L2 data were replaced by Version 1.1. The original 2009 Antarctica data were processed through a temporary process with quicklook data products only. Version 1.1 data are produced from full Synthetic Aperture Radar (SAR) processing.
V1.2	October 2011	MCoRDS L2 data were replaced by Version 1.2. The `csv_good` and `CSARP_layer` data were removed from the previous version.

4 RELATED DATA SETS

IceBridge MCoRDS L1B Geolocated Radar Echo Strength Profiles

IceBridge PARIS L2 Ice Thickness

IceBridge HiCARS 1 L2 Geolocated Ice Thickness

Greenland 5 km DEM, Ice Thickness, and Bedrock Elevation Grids

5 RELATED WEBSITES

CReSIS at KU

IceBridge data at NSIDC

IceBridge website at NASA

ICESat/GLAS at NASA

ICESat/GLAS at NSIDC

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8 DOCUMENT INFORMATION

8.1 Publication Date

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8.2 Date Last Updated

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APPENDIX A – RADAR SETTINGS

Data collection modes used for typical radar operation are described in the table below.

Table A - 1. Radar Settings for Icebridge Campaigns

Campaign	Instrument[2]	Radar settings
2009 Antarctica DC-8	MCoRDS	Bandwidth: 180–210 MHz (DC-8 platform restricted to 189.15–198.65 MHz) Tx power: 750 W, 150 W per element Waveform: 8-channel chirp generation, 14-bit ADC at 111 MHz bandpass sampling Acquisition: 8 channels Dynamic Range: waveform playlist Rx aperture: 1.5 wavelength aperture Tx aperture: 1.5 wavelength aperture; fully programmable Monostatic Rx/Tx Data rate: 12 MB/sec per channel
2009 Antarctica Twin Otter	MCoRDS	Bandwidth: 140–160 MHz Tx power: 500 W Waveform: 8-channel chirp generation Acquisition: 8 channels Rx aperture: 3 wavelength aperture Tx aperture: 3 wavelength aperture; fully programmable Bistatic Rx/Tx Data rate: 12 MB/sec per channel
2010 Greenland DC-8	MCoRDS	Tx power: 750 W, 150 W per element
2010 Greenland P-3	MCoRDS	Bandwidth: 180–210 MHz (EMI restricted to 10 MHz within 180–210 MHz most segments) Tx power: 750 W, 150 W per element Waveform: 8-channel chirp generation Acquisition: 16 channels (multiplexed on to 8 channels), 14-bit ADC at 111 MHz bandpass sampling Rx aperture: 2 wavelength, 3.5 wavelength, and 2 wavelength apertures, baseline of 6.4 m between each aperture Tx aperture: 3.5 wavelength aperture; fully programmable Mixed monostatic and bistatic tx/rx Data rate: 6 MB/sec per channel
2010 Antarctica DC-8	MCoRDS	Dynamic range: waveform playlist coupled with low-gain and high-gain channels Tx power: 750 W, 150 W per element

Campaign	Instrument[2]	Radar settings
2011 Greenland Twin Otter	MCoRDS2	Bandwidth: 180–210 MHz Tx power: 500 W Waveform: 8-channel chirp generation Acquisition: 16 channels (multiplexed onto 8 channels), 14-bit ADC at 111 MHz bandpass sampling Rx aperture: two 3 wavelength apertures with 13.8 m baseline Tx aperture: 3 wavelength aperture; fully programmable Mixed monostatic and bistatic tx/rx Data rate: 6 MB/sec per channel
2011 Greenland P-3	MCoRDS2	Bandwidth: 180–210 MHz Tx power: 1050 W, 150 W per element Waveform: 8-channel chirp generation Acquisition: 16 channels, 14-bit ADC at 111 MHz bandpass sampling Dynamic range: waveform playlist Rx aperture: 2 wavelength, 3.5 wavelength, and 2 wavelength apertures, baseline of 6.4 m between each aperture Tx aperture: 3.5 wavelength aperture; fully programmable Mixed monostatic and bistatic tx/rx Data rate: 32 MB/sec per channel
2011 Antarctica DC-8	MCoRDS	Dynamic range: waveform playlist coupled with low-gain and high-gain channels Tx power: 750 W, 150 W per element
2011 Antarctica Twin Otter	MCoRDS2	Tx power: 900 W, 150 W per element Rx aperture: two 3 wavelength apertures with 13.8 m baseline Tx aperture: 3 wavelength aperture; fully programmable
2012 Greenland P-3	MCoRDS2	Old TR switches Tx power: 1050 W, 150 W per element
2012 Antarctica DC-8	MCoRDS2	Upgraded TR switch Five receive channels Tx power: 750 W, 150 W per element
2013 Greenland P-3	MCoRDS3	Only the center (fuselage) array was installed Center array is monostatic tx/rx with seven elements Upgraded TR switch Tx power: 1050 W, 150 W per element
2013 Antarctica P-3	MCoRDS3	Tx power: 2100 W, 300 W per element
2014 Greenland P-3	MCoRDS3	Tx power: 2100 W, 300 W per element

Campaign	Instrument[2]	Radar settings
2014 Antarctica DC-8	MCoRDS3	Bandwidth: 165–215 MHz Tx power: 6000 W, 1000 W per element Waveform: Six channel chirp generation Acquisition: Six channels, 14-bit ADC at 150 MHz bandpass sampling New antenna array installed with 3 cross-track by 2 along-track elements. New higher power amplifiers installed. Modification to digital system sampling frequency to handle new bandwidth
2015 Greenland C-130	MCoRDS5	Bandwidth: 180–450 MHz (also used 180–230 MHz) Tx power: 1000 W, 500 W per element Waveform: Two channel chirp generation Acquisition: 2 channels, 12-bit ADC at 1600 MHz sampling Dynamic Range: waveform playlist Rx aperture: Two channels with 0.5 m aperture (quarter of a wavelength aperture) Tx aperture: Same as rx; each channel is fully programmable Monostatic tx/rx
2016 Greenland P-3	MCoRDS3	Tx power: 1000 W, 500 W per element
2016 Antarctica DC-8	MCoRDS3	Tx power: 6000 W, 1000 W per element
2017 Greenland P-3	MCoRDS3	Power amplifiers changed to same amplifiers that were used on the DC-8 Tx power: 3500 W, 500 W per element
2017 Antarctica P-3	MCoRDS3	Tx power: 3500 W, 500 W per element
2017 Antarctica Basler P-3	MCoRDS3	Tx power: 1800 W, 225 W per element
2018 Greenland P-3	MCoRDS3	Tx power: 3500 W, 500 W per element
2018 Antarctica DC-8	MCoRDS3	Tx power: 6000 W, 1000 W per element
2019 Greenland P-3	MCoRDS3	Tx power: 3500 W, 500 W per element
2019 Antarctica GV	MCoRDS3	Tx power: 2000 W, 500 W per element

[2]MCoRDS = Version 1, MCoRDS2 = Version 2, MCoRDS3 = Version 3, MCoRDS5 = Version 5